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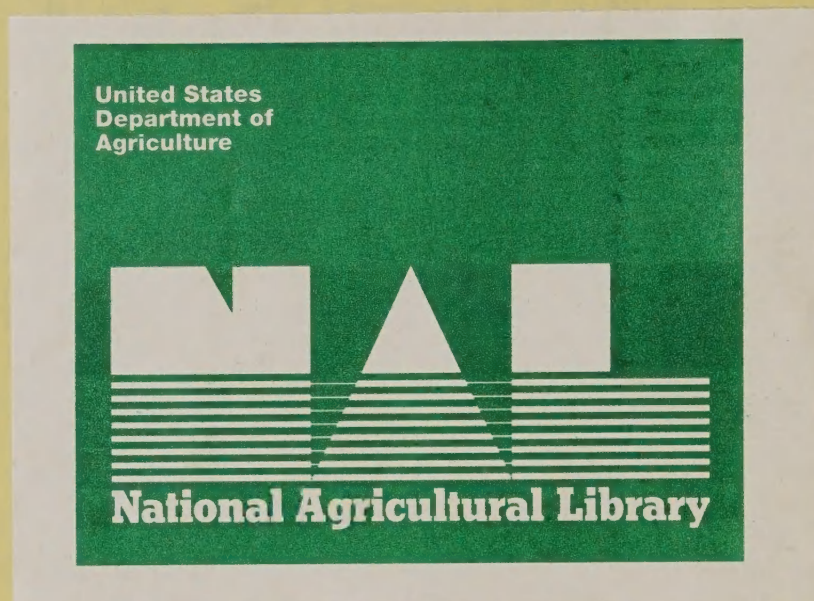
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Pesticide Assessment of Field Corn and Soybeans: Lake States

National Agricultural Pesticide Impact
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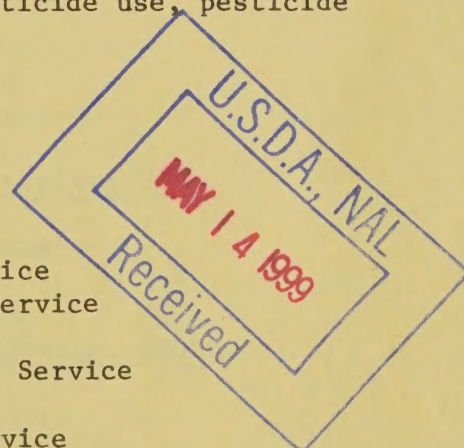
ABSTRACT

This report summarizes the pesticide assessment for corn and soybeans in the Lake States. Without insecticides, corn rootworm larvae and other soil insects would cause substantial corn yield losses. The loss of seed treatments would result in yield losses to both corn and soybeans. Among the herbicides, the loss of triazines would cause the greatest corn yield losses, while the loss of dinitroanilines would cause the greatest soybean yield losses. This report includes pest rankings, estimates of acreages treated with pesticides or other pest management practices, and estimates of pest losses with and without pesticide use, for insects, diseases, nematodes, and weeds.

Keywords: Corn, soybeans, pest losses, pest control, pesticide use, pesticide regulations

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Pesticide Assessment of Field Corn and Soybeans: Lake States

National Agricultural Pesticide Impact
Assessment Program

INTRODUCTION

This report summarizes the field corn and soybean assessment for the Lake States of Michigan, Minnesota, and Wisconsin. Included are rankings of pests in order of economic importance, pesticide use, estimates of acreages where major pesticides and other pest management practices are used, estimates of yield losses caused by pests with current practices, and estimates of losses when no pesticides are used. The estimates of losses are averaged for each State, but the losses incurred by some producers will be significantly greater than the State or regional averages.

Land planted to corn and soybeans constituted 51 percent of the land used for crops (excluding pasture or idle land) in the Lake States in 1978; corn accounted for 37 percent, while soybeans accounted for 14 percent. These States accounted for 16 percent of the U.S. acreage planted to corn and 8 percent of the U.S. acreage planted to soybeans. The average area planted to corn during 1976-80 was 2,885,000 acres for Michigan, 7,050,000 for Minnesota, and 4,010,000 for Wisconsin. The average area planted to soybeans during this same period was 838,000 acres for Michigan, 4,180,000 for Minnesota, and 243,000 for Wisconsin. The Lake States produced approximately 15 percent of the U.S. corn and 9 percent of the U.S. soybeans from 1976 to 1980.

The pesticide assessment by commodity program, a cooperative effort of the State universities and the U.S. Department of Agriculture (USDA) under the National Agricultural Pesticide Impact Assessment Program (NAPIAP) (specialists from the Minnesota State Department of Agriculture also participated), is employed because required information does not exist or has not been assembled in a readily usable format. The program improves response to Environmental Protection Agency (EPA) regulatory activity; provides information for Extension Service (ES) educational delivery systems; promotes information transfer among disciplines, regions, and States; identifies research needs and data gaps in pest control technology; and identifies emerging new pest problems.

The procedure draws upon the knowledge of experts in entomology, nematology, plant pathology, weed science, and related sciences. These experts, in consultation with colleagues both within and among disciplines, were asked to draw upon research and demonstration plots, field experience, and pest control surveys to develop the information base. Concern is always expressed over compiling information not based completely on replicated field trials or systematically planned

use surveys. However, information based on such trials has not been, and likely will not be, forthcoming for most crops and pest problems. Thus, the combined experiences of the scientists involved formed the bases for this report.

This regional pesticide assessment for field corn and soybeans represents an effort to estimate, in an orderly manner, yield losses and the effects of pesticide regulatory actions within the context of overall pest control practices. NAPIAP believes that this report and the underlying information base are useful for evaluating the effects of pesticide regulatory actions and the importance of pests. NAPIAP also believes that this study will contribute to future studies of this nature and indicate important areas for future research.

This report does not evaluate economic factors such as costs, crop prices, or pesticide price changes resulting from regulatory actions. It does not evaluate how pesticide price changes might influence pesticide use and crop losses. A future report will examine the effects of potential regulatory actions on costs and crop prices.

PROCEDURE FOR DATA COLLECTION

The NAPIAP State liaison representative for each State identified the participating specialists. The Agricultural Research Service (ARS), USDA, and the Economic Research Service (ERS), USDA, provided facilitators to guide the participants through the process.

The procedure followed several steps. All State specialists identified homogeneous production regions for corn and soybeans (equally subjected to pest problems, yield losses, and control practices). The specialists then estimated the percentage of field corn or soybeans planted under conventional, reduced, and no-till systems. Information was also included if irrigation had significantly affected pest problems.

This report presents pest and pesticide information on insects, diseases, nematodes, and weeds. For each discipline, the 15 most important pest species were ranked for each production region, based on the acreage requiring treatment, the yield and quality losses, and the probability of recurrence. Pesticide treatments were identified by active ingredient, timing of application, and percentage of planted acres treated in each production region. Target pests for treatment were identified, and estimates of the proportion of planted acres treated for each were made. Also identified were nonchemical pest management practices, the target pests, and the percentage of planted acres treated.

Registered insecticides and fungicides were identified for each target pest and ranked by efficacy of yield. Pesticides with yield effects which were not significantly different received the same ranking.

Yield and percentage of planted acres were estimated where the pests in question caused no, low, medium, and high losses under current pest control practices used by growers. Yield and/or percentage of planted acreage were revised for each impact level by assuming that the most effective pesticide(s) is no longer available for use and that other pesticides and management practices can be used. This procedure continued by removing the second, then the third, and so forth, most effective pesticide(s) in succession while revising the yield and acreage estimates. Finally, estimates were made assuming no chemical pesticide control

was available for the pest in question. Separate estimates were made for tillage systems or production regions where impacts differed.

Herbicides were not ranked by efficacy. Estimates of the effect on yield of removing important herbicides and groups of herbicides such as triazines, thiocarbamates, or phenoxy were made. First, yield estimates were made for no, low, medium, and high losses resulting from all weeds and the percentage of planted acreage for each impact level for the current pattern of weed control practices. Then, a specific herbicide or group of herbicides was assumed unavailable for use. Resulting new weed problems and alternative control practices were identified, and estimates of yield and percentage of planted acres for each new impact level were made. Next, the first herbicide or group of herbicides was assumed available for use again, while a second herbicide or group of herbicides was assumed unavailable. Then the procedure was repeated. This process continued until the effects of removing each major herbicide and group were examined. Finally, changes in cultivation practices were identified and yield effects were estimated where herbicides were unavailable.

FIELD CORN

Tillage Systems

An estimated 56 percent of the acres planted to corn in the Lake States were under conventional tillage, 37 percent under reduced tillage, and 7 percent under no-till (table 1). Wisconsin had more conventional tillage and less reduced tillage than did Michigan and Minnesota.

Insects, Insecticides, and Losses

The Lake States ranked corn rootworms as the most important pest, European corn borers second in importance, true armyworms third, and cutworms fourth (table 2). Stalk borers, the only other pest identified by all three States, ranked fifth.

Soil insecticides were the most important treatments to control corn rootworms (table 3). Terbufos and fonofos were each used on 7 percent of the acreage, carbofuran was used on 6 percent, and phorate on 5 percent. Chlorpyrifos and isofenfos were used on much less acreage. Carbofuran also controlled European corn borers on 1 percent of the acreage and stalk borers on less than 1 percent. Carbaryl, diazinon, lindane, and malathion were applied to relatively small acreages.

Scouting was the only nonpesticide management practice identified by all Lake States (table 4). Minnesota also identified crop rotation to control corn rootworms and moldboard plowing to control European corn borers.

Corn rootworms and European corn borers were the only insects estimated to cause more than a 1-percent loss in production without pesticide control (table 5). Losses from corn rootworms would increase to 3.8 percent from 0.4 percent if insecticides were no longer available. Losses from European corn borers would increase to 4.5 percent from 2 percent, with the greatest losses occurring in Wisconsin.

Table 1. Corn acreage under major tillage systems in the Lake States 1/

Tillage systems	Percentage of planted acres			
	MI	MN	WI	Region <u>2/</u>
	<u>Percent</u>			
Conventional <u>3/</u>	46	48	76	56
Reduced <u>4/</u>	50	42	19	37
No-till <u>5/</u>	4	10	5	7

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ State estimates were weighted by planted acres and averaged to obtain the regional estimates.3/ Moldboard plowing, two passes with disc or field cultivator before planting, one or more cultivations after crop emergence.4/ Disc-plowing: disc stubble one or two times before planting, one cultivation after crop emergence; chisel-plowing: chisel plow, one cultivation after crop emergence; or rotary-tillage: disc stubble, roto-till and plant in one pass, one cultivation after crop emergence.5/ No tillage operations before, during, or after planting.Table 2. Ranking of corn insect pests in the Lake States 1/

Insects	Rank <u>2/</u>			
	MI	MN	WI	Region
Corn rootworms	1	1	1	1
European corn borers	2	2	2	2
True armyworms	3	3	3	3
Cutworms	4	4	4	4
Stalk borers	5	6	7	5
Corn rootworm adults	6	5	NR	6
Grasshoppers	8	6	NR	7
Wireworms	NR	NR	5	8
White grubs	NR	NR	6	9
Seedcorn maggots	9	NR	8	10
Slugs	7	NR	NR	11
Hop vine borers	NR	7	NR	12
Cornleaf aphids	10	NR	9	13
Billbugs	NR	NR	10	14

NR = Not reported.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ 1 = Most serious, 2 = second-most serious, etc. Regional rankings were weighted averages of State-level rankings. State-level rankings were uniformly standardized so each would have the same mean and variance. The standardized variables were weighted by planted acres to construct the regional ordering.

Table 3. Corn insecticide use by timing and target pest in the Lake States 1/

Active ingredients	Timing <u>2/</u>	Target pest	Percentage of planted acres			
			MI	MN	WI	Region <u>3/</u>
<u>Percent</u>						
Carbaryl	8,10	Armyworms	1	-	1	<1
	8	Cutworms	1	-	-	<1
	8,9,10	European corn borers	1	-	-	<1
		Total	3	-	-	<1
Carbofuran	2,3	Corn rootworms	16	4	4	6
	8,9,10	European corn borers	4	<1	1	1
	2	Stalk borers	-	<1	-	<1
		Total	20	5	5	8
Chlorpyrifos	2,3	Corn rootworms	3	1	<1	1
	8,10	Other	-	1	1	<1
		Total	3	2	1	2
Diazinon	3	Corn rootworms	1	-	-	<1
	ST	Seedcorn maggots	-	-	4	1
		Total	1	-	4	1
Diazinon + lindane	ST	Seedcorn maggots	-	-	4	1
Ethoprop	3	Corn rootworms	1	-	2	<1
Fonofos	3	do.	-	8	10	7
Isofenfos	2,3	do.	1	1	3	2
Malathion	8,10	Corn leaf aphids	2	-	-	<1
Phorate	3	Corn rootworms	-	3	12	5
Terbufos	2,3	do.	3	4	15	7

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Timing of application, where:

ST = Seed treatment.

2 = In furrow at planting.

3 = At planting as a band.

8 = Postemergence foliar or over row.

9 = Postemergence whorl directed.

10 = Postemergence aerial.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Table 4. Nonpesticide corn insect management in the Lake States 1/

Insects	Insect management practice	Percentage of planted acres		
		MI	MN	WI
<u>Percent</u>				
All insects	Scouting <u>2/</u>	1	1	1
Corn rootworms	Rotation	-	50	-
European corn borers	Moldboard plowing	-	1	-

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Scouting is a pest detection practice which can lead to the use of pesticide or nonpesticide management practices.

Table 5. Average percentage corn insect yield losses in the Lake States 1/

Insects and insect control practices	Average percentage yield loss <u>2/</u>			
	MI	MN	WI	Region <u>3/</u>
<u>Percent</u>				
Armyworms:				
Current controls	-	0.1	0.1	<0.1
No pesticide controls	-	.1	2.0	.6
Corn leaf aphids:				
Current controls	1.0	-	-	.2
No pesticide controls	1.1	-	-	.2
Corn rootworms:				
Current controls	.2	.6	.3	.4
No pesticide controls	5.7	1.8	5.3	3.6
Cutworms:				
Current controls	-	.1	.2	.1
No pesticide controls	-	1.0	.9	.8
European corn borers:				
Current controls	.5	3.6	.2	2.0
No pesticide controls	1.6	4.8	6.0	4.5
Wireworms:				
Current controls	-	-	< .1	< .1
No pesticide controls	-	-	1.3	< .1

- = Insignificant yield loss.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ These estimates were averaged over the entire planted corn acres in each State. Estimates are losses from a yield where the pest causes no perceptible damage.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Diseases, Fungicides, Nematicides, and Losses

Stalk rots, especially *Gibberella*, were identified as the most important disease by all Lake States (table 6). *Fusarium* stalk rot also ranked first in Minnesota and Wisconsin, fifth in Michigan, and second in the region. Eyespot, ear and kernel rots, and common smut were identified as economically significant by all Lake States.

All of the field corn seed planted in the Lake States was treated with captan to control seed rots and seedling blights (table 7). In Wisconsin, carbofuran and terbufos were each used on 4 percent of the acreage to control nematodes. Resistant varieties, the most commonly reported disease management practice, controlled Anthracnose, ear mold, eyespot, northern corn leaf blight, northern leaf spot, smut, and stalk rots (table 8). Conventional tillage and rotation also helped control Anthracnose, eyespot, nematodes, and northern leaf spot. Disease management practices and acreages estimated by each State varied widely. No acreage estimates for nonpesticide management practices were available for Michigan.

If pesticides were no longer available, regional production losses from seed rots and seedling blights would increase from 2.1 percent to 7.2 percent (table 9). Losses from nematodes would increase only slightly if pesticides were no longer available.

Table 6. Ranking of corn diseases and nematodes in the Lake States 1/

Diseases and nematodes	Rank <u>2/</u>			
	MI	MN	WI	Region
Stalk rot (<i>Gibberella</i>)	1	1	1	1
Stalk rot (<i>Fusarium</i>)	5	1	1	2
Eyespot	NR	2	4	3
Ear and kernel rots	4	6	2	4
Common smut	6	4	9	5
Northern leaf spot	NR	5	7	6
Seed rots and seedling blights	NR	3	NR	7
Northern corn leaf blight	3	NR	5	8
Anthracnose	2	NR	6	9
Storage molds	7	NR	3	10
Nematodes	NR	8	6	11
Common rust	NR	7	NR	12
Holcus spot	NR	9	NR	13
Goss's wilt	NR	NR	8	14

NR = Not reported.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ 1 = Most serious, 2 = second-most serious, etc. Regional rankings were weighted averages of State-level rankings. State-level rankings were uniformly standardized so each would have the same mean and variance. The standardized variables were weighted by planted acres to construct the regional ordering.

Table 7. Corn fungicide and nematicide use in the Lake States 1/

Active ingredients	Timing <u>2/</u>	Target pest	Percentage of planted acres			
			MI	MN	WI	Region <u>3/</u>

<u>Percent</u>						
Captan	ST	Seed rots and seedling blights	100	100	100	100
Carbofuran	3	Nematodes	-	-	4	1
Terbufos	3	Nematodes	-	-	4	1

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Timing of application, where:

ST = Seed treatments (including planter box treatments); 3 = banded, at planting.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Table 8. Nonpesticide corn disease and nematode management in the Lake States 1/

Diseases and nematodes	Disease/nematode management practice	Percentage of planted acres		
		MI	MN	WI

<u>Percent</u>				
Anthracnose	Conventional tillage	-	-	5
	Resistant varieties	u	-	5
	Rotation	-	-	5
Earmold	Resistant varieties	u	-	-
Eyespot	Conventional tillage	-	-	50
	Resistant varieties	u	25	50
	Rotation	-	-	50
Nematodes	Conventional tillage	-	-	5
	Crop rotation	u	-	5
Northern corn leaf blight	Resistant varieties	u	-	20
Northern leaf spot (Helminthosporium)	Conventional tillage	-	-	10
	Resistant varieties	u	25	10
	Rotation	-	-	10
Smut	Resistant varieties	-	40	-
Stalk rots	Fertility balance	-	-	80
	Resistant varieties	-	85	80
Storage molds	Drying and aeration	-	-	75

- = Insignificant acreage.

u = Practice important but no estimate of acreage provided.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

Table 9. Average percentage corn yield losses from diseases and nematodes controlled with pesticides in the Lake States 1/

Diseases, nematodes, and control practices	Average percentage yield loss <u>2/</u>			
	MI	MN	WI	Region <u>3/</u>
	<u>Percent</u>			
Seed rots and seedling blights:				
Current controls	0.1	1.7	3.8	2.1
No pesticide controls	1.0	11.7	3.9	7.2
Nematodes:				
Current controls	-	-	1.2	.3
No pesticide controls	-	-	1.5	.4

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ These estimates were averaged over the entire planted acres in each State. Estimates are losses from a yield where the pest causes no perceptible loss.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Weeds, Herbicides, and Losses

Weed rankings for the Lake States were based on Minnesota and Wisconsin data because Michigan provided no weed information. Common lambsquarters, green foxtail, redroot pigweed, giant foxtail, and velvetleaf were the five most important weed pests (table 10). Common lambsquarters ranked highest even though it ranked second in each State. Green foxtail ranked second in the region, first in Minnesota, and eighth in Wisconsin. Giant foxtail ranked fourth in the region, first in Wisconsin, and sixth in Minnesota.

Atrazine and alachlor were the most popular herbicides, used on approximately 41 percent and 42 percent of the acreage, respectively (table 11). These herbicides were used individually, in various mixes, or sometimes mixed with each other (on 20 percent of the acreage). Alachlor was mixed with cyanazine and dicamba, while atrazine was mixed with butylate, cyanazine, EPTC, metolachlor, pendimethalin, and simazine. Butylate, cyanazine, and metolachlor were applied to 7 percent, 8 percent, and 9 percent of the acreage, respectively (individually and in tank mixes). EPTC and propachlor were each used on about 4 percent of the acreage. Postemergence herbicides, dicamba and 2,4-D, were applied to 8 percent and 15 percent of the acreage, respectively, while a mix of these materials was applied to 10 percent. These postemergence herbicides were often applied in sequence with other herbicides.

Wisconsin was the only State that identified nonpesticide weed management practices, including fall moldboard plowing, rotation with alfalfa, and row cultivation (table 12).

Weeds caused an estimated 16.2-percent production loss to corn (table 13). Of the individual chemicals, the greatest losses would occur if atrazine were no longer available, increasing to 17.4 percent. Greater losses would occur if entire groups of herbicides were taken off the market. Losses would increase to 25.7 percent if no triazines were available and to 24.1 percent if no acetanilides were available. If no herbicides were available, losses would be even greater, increasing to 39.5 percent with current cultivation and to 31.2 percent with extra cultivation.

Table 10. Ranking of corn weed pests in the Lake States 1/

Weeds	Rank <u>2/</u> <u>3/</u>		
	MN	WI	Region
Common lambsquarters	2	2	1
Green foxtail	1	8	2
Redroot pigweed	3	3	3
Giant foxtail	6	1	4
Velvetleaf	5	5	5
Yellow foxtail	4	12	6
Quackgrass	8	4	7
Common ragweed	8	10	8
Common cocklebur	6	NR	9
Pennsylvania smartweed	7	NR	10
Canada thistle	8	15	11
Wild proso millet	NR	6	12
Fall panicum	NR	7	13
Yellow nutsedge	NR	9	14
Robust foxtail (green, white, purple)	9	NR	15
Wild mustard	9	NR	15
Crabgrass	NR	11	17
Giant ragweed	10	NR	18
Barnyardgrass	10	NR	18
Shattercane	NR	13	20
Woolly cupgrass	NR	14	21

NR = Not reported.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Michigan provided no estimates.

3/ 1 = Most serious, 2 = second-most serious, etc. Regional rankings were weighted averages of State-level rankings. State-level rankings were uniformly standardized so each would have the same mean and variance. The standardized variables were weighted by planted acres to construct the regional ordering.

Table 11. Corn herbicide use in the Lake States 1/

Active ingredients	Percentage of planted acres <u>2/</u>		
	MN	WI	Region <u>3/</u>
	<u>Percent</u>		
Alachlor	29	-	18
Atrazine	13	8	11
Butylate	4	-	3
Cyanazine	4	2	3
Dicamba	12	1	8
EPTC	7	-	4
Metolachlor	4	-	3
Paraquat	-	1	<1
Propachlor	7	-	4
2,4-D	19	9	15
Alachlor + atrazine	11	35	20
Alachlor + cyanazine	6	1	4
Alachlor + atrazine + cyanazine	1	-	<1
Alachlor + dicamba	-	2	<1
Atrazine + butylate	-	9	3
Atrazine + cyanazine	-	1	<1
Atrazine + EPTC	-	2	<1
Atrazine + metolachlor	2	12	6
Atrazine + oil	2	-	1
Atrazine + pendimethalin	-	1	<1
Atrazine + simazine	-	1	<1
Butylate + cyanazine	-	3	1
Cyanazine + EPTC	-	1	<1
Cyanazine + metolachlor	-	2	<1
Cyanazine + pendimethalin	-	2	<1
Dicamba + 2,4-D	15	1	10
Metolachlor + simazine	-	1	<1

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Michigan provided no estimates.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Table 12. Nonpesticide corn weed management in the Lake States 1/

Corn weed management practices	Percentage of planted acres: WI <u>2/</u>
	<u>Percent</u>
Fall moldboard plowing	76
Rotation with alfalfa	25
Row cultivation	35

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ Michigan and Minnesota provided no estimates.Table 13. Average percentage corn weed yield losses in the Lake States 1/

Weed control practices	Average percentage yield loss <u>2/</u> <u>3/</u>		
	MN	WI	Region <u>4/</u>
	<u>Percent</u>		
Current controls <u>5/</u>	12.5	22.7	16.2
Remove: <u>6/</u>			
Atrazine	12.5	26.1	17.4
Butylate	12.5	22.9	16.3
Cyanazine	12.5	23.5	16.5
Dicamba	12.5	22.9	16.3
EPTC	12.5	23.0	16.3
Glyphosate	12.5	23.7	16.6
Paraquat	12.5	23.2	16.4
Pendimethalin	12.5	23.0	16.3
Simazine	12.5	22.8	16.5
2,4-D	12.5	23.4	16.5
Acetanilides	18.6	33.8	24.1
Thiocarbamates	12.5	23.0	16.3
Triazines	18.8	37.9	25.7
No chemical controls:			
With current cultivation	32.9	51.0	39.5
With extra cultivation	24.8	42.5	31.2

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ These estimates are average yield losses over the entire planted acreage in the State from a maximum where weeds cause no perceptible loss. Other problems and farm management practices were held constant.3/ Michigan provided no estimates.4/ State estimates were weighted by planted acres and averaged to obtain regional estimates.5/ These estimates assume the current pattern of weed control practices in each State.6/ These estimates assume that only the specific herbicide or herbicide group is no longer available for use. Other herbicides or control practices were substituted and all other pest problems and farm management practices were held constant.

SOYBEANS

Tillage Systems

An estimated 55 percent of the soybean acreage in the Lake States was under conventional tillage, 45 percent under reduced tillage, and less than 1 percent under no-till planting (table 14). In Wisconsin, 75 percent of the acreage was under conventional tillage.

Insects, Insecticides, and Losses

Michigan, the only State to identify insects as important soybean pests, reported green cloverworms, cutworms, spider mites, and potato leafhoppers as the four most important insect pests (table 15). Approximately 20 percent of the Michigan acreage received carbaryl treatments, which were equally distributed to control green cloverworms and potato leafhoppers (table 16). Dimethoate was also used on 5 percent of the Michigan acreage to control potato leafhoppers. Scouting occurred on approximately 1 percent of the Michigan soybean acreage (table 17). Soybean losses caused by green cloverworms would increase to 2.8 percent from 1.2 percent if pesticides were no longer available (table 18). Losses from potato leafhoppers would increase from 1.4 percent to 3 percent without pesticides. Yield losses in the Lake States caused by removing soybean insecticides from the market would be less than 1 percent.

Table 14. Soybean planted acreage under major tillage systems in the Lake States 1/

Tillage systems	Percentage of planted acres			
	MI	MN	WI	Region <u>2/</u>
	<u>Percent</u>			
Conventional <u>3/</u>	48	55	75	55
Reduced <u>4/</u>	50	<u>6/</u> 45	20	45
No-till <u>5/</u>	2	NR	5	<1

NR = Not reported.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ State estimates were weighted by planted acres and averaged to obtain the regional estimates.

3/ Moldboard plowing, two passes with disc or field cultivator before planting, one or more cultivations after crop emergence.

4/ Disc-plowing: disc stubble one or two times before planting, one cultivation after crop emergence; chisel-plowing: chisel plow, one cultivation after crop emergence; rotary-tillage: disc stubble, roto-till and plant in one pass, one cultivation after crop emergence; or ridge tillage.

5/ No tillage operations before, during, or after planting.

6/ Includes 7 percent under ridge tillage.

Table 15. Ranking of soybean insect pests in the Lake States 1/

Insects	Rank: MI <u>2/</u> <u>3/</u>
Green cloverworms	1
Cutworms	2
Spider mites	3
Potato leafhoppers	4
Leaf beetles	5
Seedcorn maggots	6
Junebug adults	7
Mexican bean beetles	8
Slugs	9

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Minnesota and Wisconsin did not consider soybean insects to be a significant problem and provided no information.

3/ 1 = Most important, 2 = second-most important, etc.

Table 16. Soybean insecticide use by timing and target pest in the Lake States 1/

Active ingredients	Timing <u>2/</u>	Target pest	Percentage of planted acres: MI <u>3/</u>
			<u>Percent</u>
Carbaryl	8, 10	Green cloverworms	10
	8, 10	Potato leafhoppers	10
		Total	20
Dimethoate	8, 10	Potato leafhoppers	5

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Timing of application, where:

8 = Postemergence foliar over row.

10 = Postemergence broadcast (aerial).

3/ Minnesota and Wisconsin did not consider soybean insects to be a significant problem and provided no information.

Table 17. Nonpesticide soybean insect management in the Lake States 1/

Insects	Insect management practice	Percentage of planted acres: MI <u>2/</u>
		<u>Percent</u>
All insects	Scouting <u>3/</u>	1

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ Minnesota and Wisconsin did not consider soybean insects to be a significant problem and provided no information.3/ Scouting is a pest detection practice which can lead to the use of pesticide or nonpesticide management practices.Table 18. Average percentage soybean insect yield losses in the Lake States 1/

Insects and insect control practices	Average percentage yield loss <u>2/</u> <u>3/</u>	
	MI	Region <u>4/</u>
<u>Percent</u>		
Green cloverworms:		
Current controls	1.2	0.2
No pesticide controls	2.8	.4
Potato leafhoppers:		
Current controls	1.4	.2
No pesticide controls	3.0	.5

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ These estimates were averaged over the entire planted soybean acres in each State. Estimates are losses from a yield where the pest causes no perceptible damage.3/ Minnesota and Wisconsin did not consider soybean insects to be a significant problem and provided no information.4/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Diseases, Fungicides, and Losses

The Lake States identified Phytophthora rot, seed rots and seedling blights, brown stem rot, pod and stem blight, and stem canker as the five most important soybean disease pests (table 19). Phytophthora rot ranked first in Michigan and Minnesota but second in Wisconsin. Wisconsin ranked brown stem rot first. Phytophthora rot, seed rots, seedling blights, brown stem rot, brown spot, and Sclerotinia stem rot were the only pests identified by all three Lake States.

The most important fungicides applied were seed treatments, used primarily in Minnesota (table 20). Captan was applied to an estimated 59 percent of the acreage in the region, including 74 percent in Minnesota and 5 percent in Wisconsin. Metalaxyl was also used on a small acreage to control seedling diseases. Metalaxyl, thiram, captan plus metalaxyl, and thiram plus carboxin controlled Phytophthora.

Resistant varieties were identified as the most common nonpesticide disease management practice (table 21). Resistant varieties controlled brown stem rot, downy mildew, Phytophthora root rot, pod and stem blight, and Sclerotinia, while full-season varieties controlled brown spot, brown stem blight, pod and stem blight, and stem canker. Drainage, long rotations, and seedbed preparation were also important practices to control Phytophthora root rot in Minnesota.

Removing soybean fungicides from the market would have little effect on regional soybean yield losses (table 22). Without pesticides, losses from seed rots and seedling blights would increase from 1.4 percent to 1.7 percent. The estimated losses from these diseases were greater in Wisconsin.

Weeds, Herbicides, and Losses

Soybean weed estimates for the Lake States were based entirely on Minnesota and Wisconsin data because Michigan provided no information. The six most important weed pests were green foxtail, common lambsquarters, redroot pigweed, yellow foxtail, velvetleaf, and cocklebur (table 23). Green foxtail ranked first in Minnesota, while giant foxtail ranked first in Wisconsin.

Alachlor and trifluralin were the two most widely used soybean herbicides (table 24). Alachlor was used on 27 percent of the acreage, with 14 percent applied individually and 13 percent in various mixes. Alachlor plus linuron was applied to 15 percent of the acreage, but alachlor was also mixed with chloramben, fluchloralin, and metribuzin. Trifluralin was applied to 53 percent of the acreage, with 39 percent applied individually and 14 percent in various mixes. Trifluralin mixes with chloramben or metribuzin were each applied to 7 percent of the acreage. Other important herbicides included bentazon, applied to 14 percent of the acreage; chloramben to 15 percent; linuron to 15 percent; and metribuzin to 10 percent. Herbicides used less widely were acifluorfen on 1 percent of the acreage, fluchloralin on 4 percent, glyphosate on 2 percent, and metolachlor on 2 percent.

Each State identified different nonpesticide weed management practices (table 25). Minnesota pulled and hoed, while Wisconsin rotated, cultivated, and spaced narrow rows.

Table 19. Ranking of soybean disease and nematode pests in the Lake States 1/

Diseases and nematodes	Rank <u>2/</u>			
	MI	MN	WI	Region
Phytophthora rot	1	1	2	1
Seed rots and seedling blights	4	2	3	2
Brown stem rot	3	5	1	3
Pod and stem blight	NR	3	4	4
Brown spot	7	4	5	5
Stem canker	NR	3	6	6
Anthracnose	NR	7	NR	7
Sclerotinia stem rot	2	10	4	8
Downy mildew	NR	6	NR	9
Viruses	7	9	NR	10
Nematodes	NR	8	NR	11
Rhizoctonia root rot	5	NR	NR	12
Bacterial diseases (blight, pustule)	7	11	NR	13
Fusarium root rot	6	NR	NR	14

NR = Not reported.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ 1 = Most serious, 2 = second-most serious, etc. Regional rankings were weighted averages of State-level rankings. State-level rankings were uniformly standardized so that each would have the same mean and variance. The standard variables were weighted by planted acres to construct the regional ordering.

Table 20. Soybean fungicide use in the Lake States 1/

Active ingredients	Timing <u>2/</u>	Target pest	Percentage of planted acres			
			MI	MN	WI	Region <u>3/</u>
<u>Percent</u>						
Benomyl	7	Sclerotinia	-	-	1	<1
Captan	ST	Seed rots and seedling blights	-	74	5	59
Metalaxyl	ST	do.	1	3	-	3
Metalaxyl	ST	Phytophthora root rot	4	-	-	<1
Thiram	ST	do.	-	17	-	13
Captan + Metalaxyl	ST	do.	-	6	-	5
Thiram + Carboxin	ST	do.	-	-	5	<1

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.2/ Timing of application, where: ST = seed treatments and 7 = foliar diseases.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Table 21. Nonpesticide soybean disease and nematode management in the Lake States 1/

Diseases and nematodes	Disease/nematode management practices	Percentage of planted acres		
		MI	MN	WI
		<u>Percent</u>		
Brown spot	Conventional tillage	-	-	1
	Full season varieties	-	-	1
	Rotation	-	-	1
Brown stem rot	Resistant varieties	-	40	30
	Rotation	-	-	30
Cyst nematodes	do.	-	3	-
Downy mildew	Resistant varieties	-	80	-
Phytophthora root rot	Drainage	<1	70	-
	Field selection	-	-	70
	Long rotations	2	70	-
	Resistant varieties	20	-	70
	Seedbed preparation	-	70	-
Pod and stem blight	Conventional tillage	-	-	5
	Full season varieties	-	-	5
	Rotation	-	-	5
	Resistant varieties	-	40	-
Sclerotinia	do.	-	-	5
	Rotate to wheat or corn	2	-	-
	Wider row spacing	-	-	5
Seed rots and seedling blights	Delayed planting	-	-	5
	Replanting	<1	-	-
Stem canker	Conventional tillage	-	-	1
	Full-season varieties	-	-	1
	Rotation	-	-	1

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

Table 22. Average percentage soybean yield losses from diseases treated with fungicides in the Lake States 1/

Diseases, nematodes, and control practices	Average percentage yield loss <u>2/</u>			
	MI	MN	WI	Region <u>3/</u>
	Percent			
Phytophthora root rot:				
Current controls	2.0	-	-	0.3
No pesticide controls	2.0	-	-	.3
Sclerotinia:				
Current controls	1.7	-	-	.3
No pesticide controls	1.7	-	-	.3
Seed rots and seedling blights:				
Current controls	1.6	1.1	6.7	1.4
No pesticide controls	1.6	1.3	9.6	1.7

- = Insignificant yield loss.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ These estimates were averaged over the entire planted acres in each State. Estimates are losses from a yield where the pest causes no perceptible loss.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Table 23. Ranking of soybean weed pests in the Lake States 1/

Weeds	Rank <u>2/</u> <u>3/</u>		
	MN	WI	Region
Common lambsquarters	2	2	1
Green foxtail	1	7	2
Redroot pigweed	3	4	3
Velvetleaf	6	3	4
Yellow foxtail	4	NR	5
Giant foxtail	11	NR	6
Cocklebur	5	NR	7
Common ragweed	10	10	8
Robust green foxtail	7	NR	9
Wild mustard	8	NR	10
Quackgrass	11	12	11
Canada thistle	9	NR	12
Wild proso millet	NR	5	13
Yellow nutsedge	15	9	14
Black nightshade	NR	6	15
Pennsylvania smartweed	12	NR	16
Ladysthumb smartweed	NR	8	17
Giant ragweed	13	NR	18
Barnyardgrass	14	NR	19
Wooly cupgrass	NR	13	20
Common milkweed	NR	14	21
Volunteer corn	16	NR	22
Hedge bindweed	NR	15	23

NR = Not reported.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Michigan provided no estimates.

3/ 1 = Most serious, 2 = second-most serious, etc. Regional rankings were weighted averages of State-level rankings. State-level rankings were uniformly standardized so each would have the same mean and variance. The standardized variables were weighted by planted acres to construct the regional ordering.

Weeds caused an estimated 15-percent production loss to soybean acreage. Of the individual chemicals, removing bentazon from the market would cause the greatest increase in losses--to 16.5 percent. Removing alachlor, linuron, and metribuzen would reduce production very little. Removing all dinitroanilines from the market would increase soybean weed losses to 17.4 percent. Losses would increase to 15.3 percent if no acetanilides were available. Without any herbicides, losses from weeds would be much greater, increasing to 42.6 percent with current cultivation and to 36.2 percent with extra cultivation.

Table 24. Soybean herbicide use in the Lake States 1/

Active ingredients	Percentage of planted acres <u>2/</u>		
	MN	WI	Region <u>3/</u>
	<u>Percent</u>		
Acifluorfen	1	2	1
Alachlor	14	10	14
Bentazon	14	20	14
Chloramben	11	2	11
Fluchloralin	2	2	2
Glyphosate	2	-	2
Metolachlor	2	1	2
Pendimethalin	-	1	<1
Trifluralin	41	8	39
Alachlor + chloramben	4	5	4
Alachlor + fluchloralin	2	-	2
Alachlor + linuron	4	15	4
Alachlor + metribuzin	2	25	3
Metolachlor + chloramben	-	1	<1
Metolachlor + linuron	-	2	<1
Metolachlor + metribuzin	-	6	<1
Pendimethalin + chloramben	-	1	<1
Pendimethalin + linuron	-	1	<1
Pendimethalin + metribuzin	-	2	<1
Trifluralin + chloramben	7	2	7
Trifluralin + metribuzin	7	15	7

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Michigan provided no information for soybean weeds.

3/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

Table 25. Nonpesticide soybean weed management in the Lake States 1/

Nonpesticide weed controls	Percentage of planted acres <u>2/</u>	
	MN	WI
	<u>Percent</u>	
Crop rotation	-	80
Cultivation	-	50
Narrow rows	-	40
Pull and hoe	25	-

- = Insignificant acreage.

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ Michigan did not provide estimates for soybeans.

Table 26. Average percentage soybean weed yield losses in the Lake States 1/

Weed control practices	Average percentage yield loss <u>2/</u> <u>3/</u>		
	MN	WI	Region <u>4/</u>
	<u>Percent</u>		
Current controls <u>5/</u>	14.5	24.4	15.0
Remove: <u>6/</u>			
Acifluorfen	14.5	24.4	15.0
Alachlor	14.5	26.0	15.1
Bentazon	16.0	26.0	16.5
Chloramben	14.5	24.4	15.0
Fluchloralin	14.5	24.4	15.0
Glyphosate	14.5	24.4	15.0
Linuron	14.5	26.0	15.1
Metolachlor	14.5	24.4	15.0
Metribuzin	14.5	30.0	15.3
Pendimethalin	14.5	24.4	15.0
Trifluralin	14.5	24.4	15.0
Acetanilides	14.5	30.0	15.3
Dinitroanilines	17.0	24.4	17.4
No chemical controls:			
With current cultivation	40.8	75.6	42.6
With extra cultivation	34.5	66.7	36.2

1/ Corn and Soybean Commodity Assessment, NAPIAP, USDA.

2/ These estimates are average yield losses over the entire planted acres in the State from a maximum where weeds cause no perceptible loss. Other pest problems and farm management practices were held constant.

3/ Michigan provided no estimates for soybeans.

4/ State estimates were weighted by planted acres and averaged to obtain regional estimates.

5/ These estimates assume the current pattern of weed control practices in each State.

6/ These estimates assume that only the specific herbicide or herbicide group is no longer available for use. Other herbicides or control practices were substituted, and all other pest problems and farm management practices were held constant.

RESEARCH AND DATA NEEDS

The field corn and soybean pesticide assessment reveals several important research and data needs. First, State and Federal pesticide use surveys should continue in order to provide current information. The surveys should identify the major target pests for pesticide treatments. These surveys need to identify the relative importance of nonpesticide pest management practices. There are wide variations in the practices identified and the estimates of use between States. Therefore, State pest control experts should develop standardized definitions of practices and identify practices to be included in survey questionnaires.

Second, there should be more empirical field research concerning pest damage to crop yield and quality because satisfactory baseline data do not exist for many economic analyses. Existing projects which estimate pest damage under various circumstances should be expanded to include how pests interact to damage crops and how additional factors such as climate influence crop damage and quality. Research should also estimate the extent of various degrees of yield and quality damage.

These needs might be accomplished by sampling farmers' fields over a number of years to estimate pest infestations and their effect on yield and quality. With such studies, researchers could project the likelihood of various degrees of pest damage. Such research would provide a stronger basis for estimating the economic effects of potential regulatory actions and the production effects of new and improving technologies.

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